How to build low cost eye tracking glasses for head mounted system

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Abstract

This paper is a short tutorial that shows step by step how to construct low cost head gear to eye gaze tracking. It contains what kind of parts are used and what modifications must be done. The glasses are designed to work with algorithms in the infrared range (dark pupil). They were tested with open source system: *The ITU Gaze Tracker*[1] *[04]*. It works very well. Proposed solution was made from off-the-shelf parts available on the market.

Keywords: eye tracking glasses head mounted system eye gaze tracking

1. Introduction

Proposed solution was made from off-the-shelf parts available on the market. Total construction cost of glasses is about 30€. Construction of eye gaze tracking glasses are modeled on articles [01,02,03,04] and the tests carried out during the construction. The frames of safety glasses are main part of the design. A fat aluminum wire which is a handle for USB cable and capture module is attached to the glasses frames. Capture module consists of modified camera (Microsoft lifeCam VX-1000) and IR LEDs. Eye image is transmitted to the computer using the USB connector. Construction of glasses can be divided into three stages: the creation of the capture module, mounting hardware and the creation of infrared illumination. In (Table 1.1) is a list of items that were used during the construction of glasses (in metric units).

Part name	**Quantity**
Webcam Mixrosoft LifeCam VX-1000	1
Safety glasses	1
IR LED	3
Carbon resistor 1/4W 22R	1
Negative film	20 cm
Aluminum wire ø 5mm	30 cm
Mounting strips 2.4mm x 100mm	5
Heat shrinkable tubin ø 10mm	15 cm

Table 1.1: List of elements used in glasses for eye gaze tracking

[1] URL: http://www.gazegroup.org/

Figure 1.1: Elements of eye gaze tracking glasses: 1) heat shrinkable tubin, 2) negative film, 3) carbon resistor, 4) mounting strips, 5) aluminum wire, 6) IR LEDs, 7) Webcam LifeCam VX-1000, 8) safety glasses

2. The creation of the capture module

Capture module is responsible for providing an image of the eye to the computer. It was created with the Microsoft LifeCam VX-1000 (Fig. 1.1/7). Module is located near the eye (approximately 5 cm), therefore it must be small as possible.

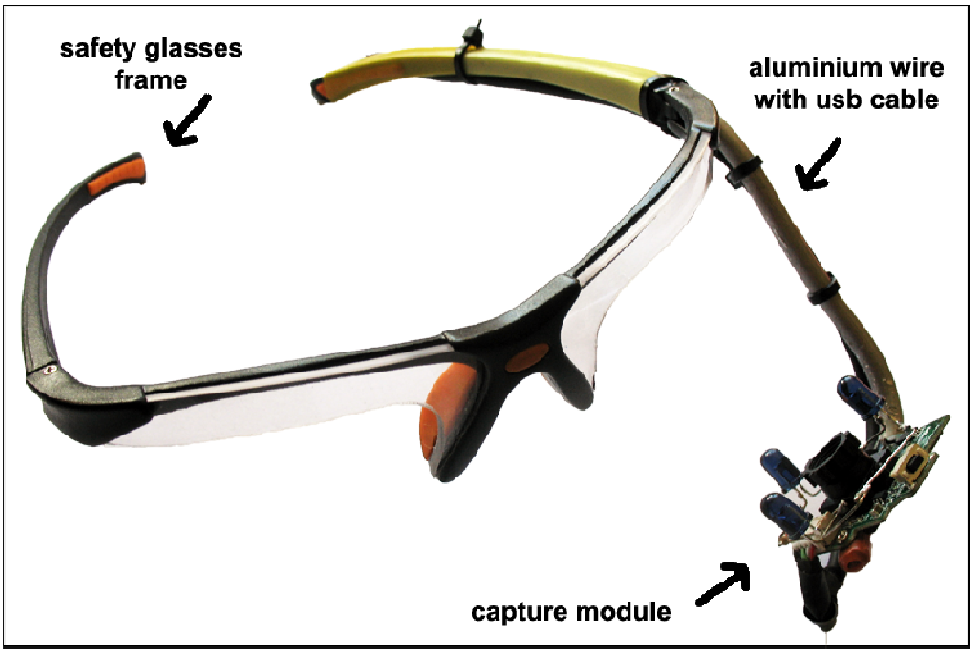


Figure 2.1: Eye gaze tracking glasses

ITU Gaze Tracker software uses algorithms based on the image obtained in infrared light. Available webcams work in the visible spectrum. It is necessary to modify the camera and mount a suitable filter that allows capturing images in infrared light. The first step in modify a webcam is a complete disassembly of the outer casing. At the back of the camera is a screw, unscrew it and then release marked place (Fig. 2.3A). The chip with a photosensitive sensor and lens of the camera is located inside. The next step is removal a additional functions button located at the top of the casing and microphone (Fig. 2.3B). To completely remove the integrated circuit constructor has to unscrew two screws, unplug the connector cables and cut off power cables of microphone (Fig. 2.3C). This integrated circuit is a core element of the capture module in the structure of glasses. The key operation of the capture module is to transfer images took in the infrared to a computer. In the camera lens should be installed filter that stops the rays of visible light and transmits infrared rays. (Fig. 2.3E) shows unscrew lens camera Microsoft LifeCam VX-1000 with built-in visible light filter (glass box). It allows webcam to capture images in a way similar to the human eye. The filter was removed by undermining its banks by thin knife. In place of it is added infrared filter. Professional IR filters are relatively expensive. Their prices start at 20€ upwards. Foundation to create eye glasses to gaze tracking was minimize the cost according to needs. Infrared filter in construction of the capture module was created from negative film. This academicals solution seems not very professional however, brings the intended results. Most relevant piece is at beginning of the film frame just before the first photo shoot and is uniformly black. Used to color film (black and white film cannot achieve the desired effect). Square was cut of the film portion of the size such as disassembled filter (approximately 5mm x 5mm) and then placed in the recess of the lens (Fig. 2.3F). When appropriately tight fits is not necessary to use glue. So the modified lens is mounted back on the chip. Capture module is ready.

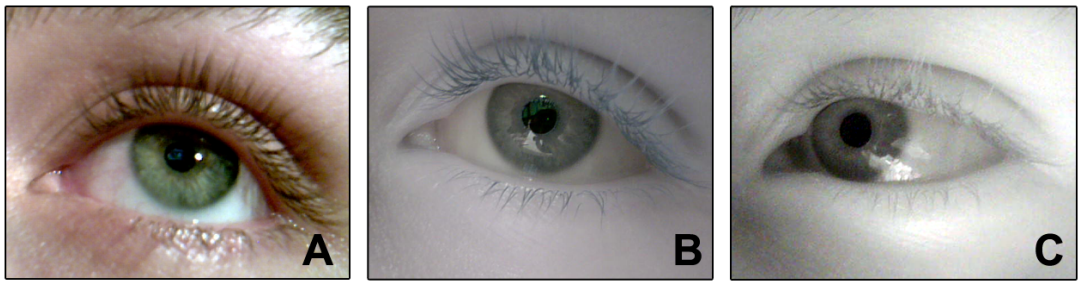


Figure 2.2: The eye image obtained from a camera: A) without modification, B) without the filter of visible light, C) with IR filter

In the final stage of extraction of a webcam is to prepare the cable connecting the module to the computer. Turning clip allows to easily remove the remains of the camera body (Fig. 2.3G). Use a sharp knife to removed rubber protection cable ends (Fig. 2.3H). Consequently, the current modifications received a minimalist version of the camera Microsoft LifeCam VX-1000 in the form of an integrated circuit which will record the image in the infrared spectrum. To check whether the camera works just plug in module and display the image on the screen. Below (Fig. 2.2) shows three consecutive images obtained from the camera during the modification.

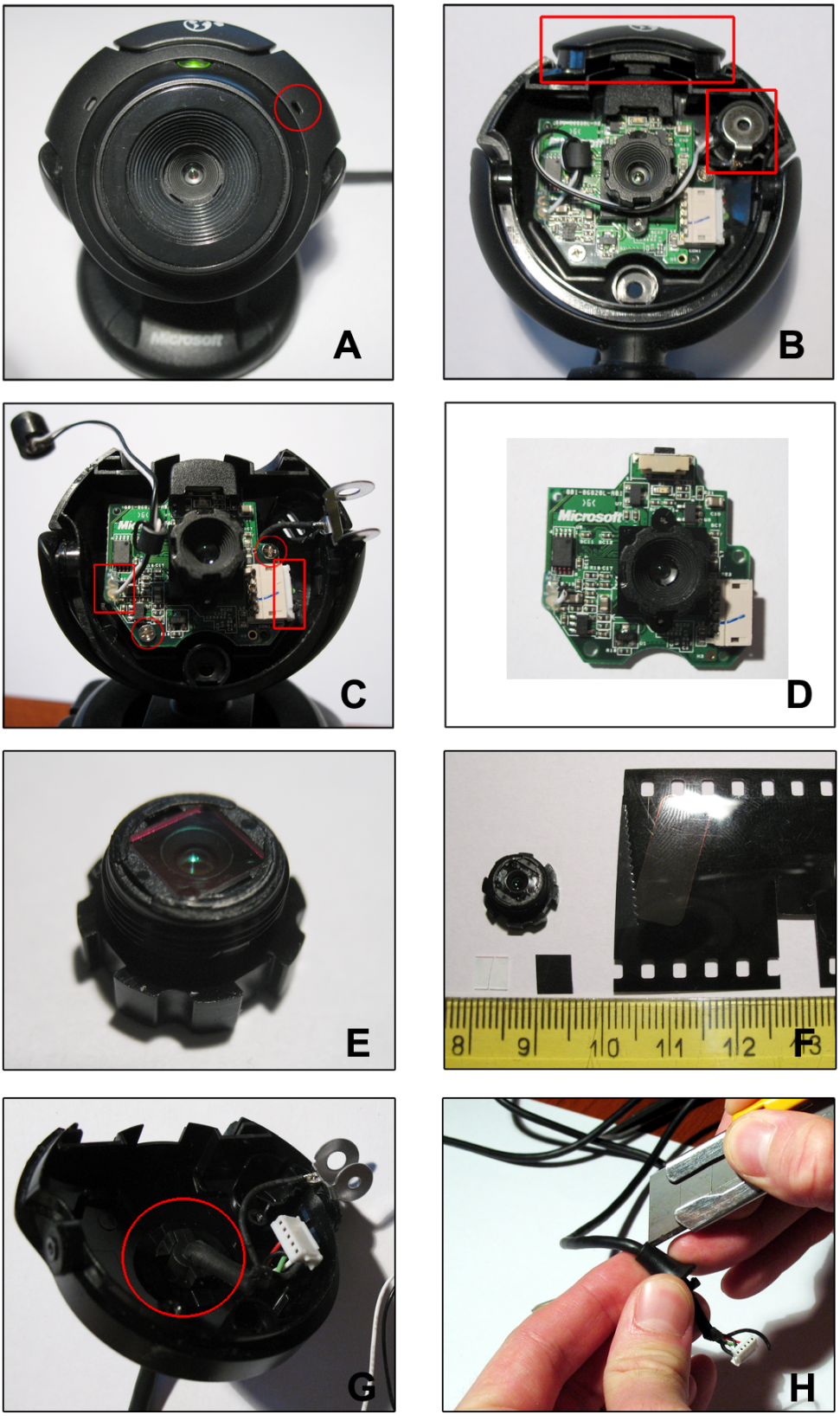
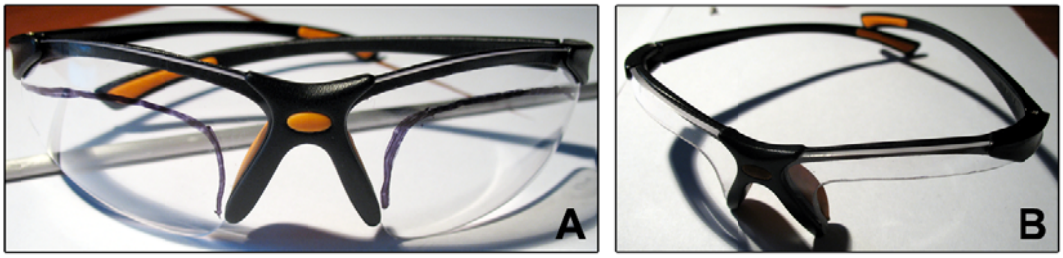


Figure 2.3: Extraction of the webcam Microsoft LifeCam VX-1000: A) removing the casing B) removing the button and the microphone C) dismantling integrated circuit D) capture module E) the camera lens with a filter of visible light F) infrared light filter assembly G) removing the cable housing H) remove unnecessary elements of the cable

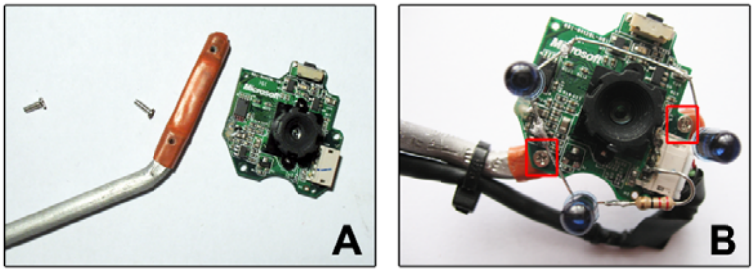
3. Mounting hardware

Modified safety glasses are a main part of the construction. This modification needs properly cut and milling. An initial outline shown in (Fig. 3.1a) and the final shape of the glasses shown (Figure 3.1B).



Rys. 3.1: Preparation of glasses frames: A) without modification but with the cutting line B) final shape

Aluminum wire is mounted to the so-prepared frames. Capture module was placed at the end of the wire. The end of the rod is flattened and insulated by heat shrinkable tubin (Fig. 3.2). In addition, two holes were drilled (the distance between the holes is the same as on the plate) to attach the webcam with screws. (Fig. 3.2B).



Rys. 3.2: Arm of capture module: A) preparing the tip of wire B) integrated circuit installation

(Fig. 3.2B) shows the IR LEDs arranged - more on this in the next section of work. Thus prepared arm is fixed to the frames of glasses (left) with mounting straps and shrink shirts. The end of the arm has been uplifted in such a way that cam observing the center of eye. As can be seen (Fig. 3.3) bending angle of aluminum wire is about 50 degrees with respect to the plane formed by the side of the glasses.

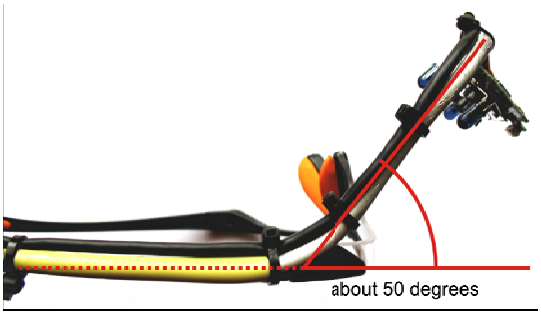


Figure 3.3: Bending angle of aluminum wire

4. The creation of infrared illumination

Three IR LEDs were mounted in the capture module. Their arrangement is shown in (Fig. 3.2B). The module is connected to a computer via USB. Taking advantage of the technical specification for USB pins are set, respectively (based on the color of the cable attached to the pin): +5 V / red, D-data transmission / white, data D + / Green and ground GND / black. This allowed to attach LEDs directly to pins at the same time eliminating the need for additional wiring and power. Circuit with three LEDs was attached to the pin marked in red and black (Fig. 4.1).

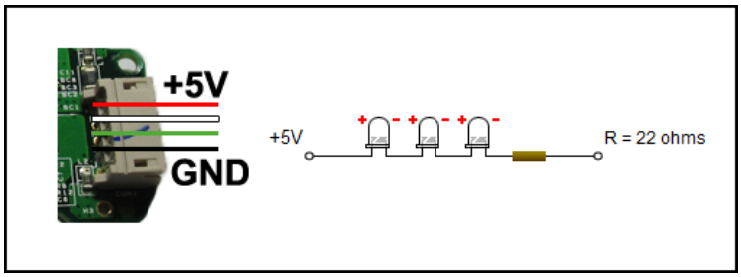


Figure 4.1: LED connection diagram

Finally glasses look like (Fig. 4.2).

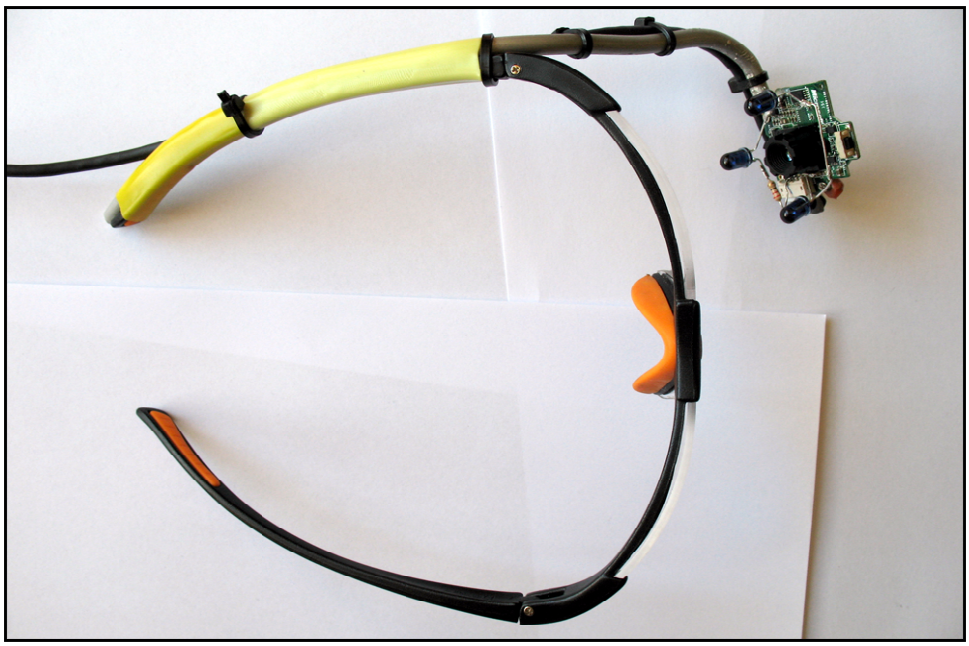


Fig. 4.2: Eye gaze tracking glasses

5. Conclusion

Technological progress has allowed for the reduction in construction costs of specialized equipment. This text shows how to build eye gaze tracking glasses for less than 50€. Glasses works very well with the *ITU Gaze Tracker* software in real time (Fig. 5.1).

Figure 5.1: ITU Gaze Tracker 1.6 in collaboration with the eye gaze tracking glasses

6. References

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